A NEW GENUS AND SUBFAMILY OF SCORPIONS FROM LOWER CRETACEOUS BURMESE AMBER (SCORPIONES: CHAERILIDAE)

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Abstract:

Electrochaerilus buckleyi sp. nov., *Electrochaerilus* gen. nov., and Electrochaerilinae subfam. nov. are described from Lower Cretaceous Burmese amber (Burmite) (Upper Albian; approximate age 98.9–112.2 Ma) from Burma (Myanmar). The observable trichobothrial pattern of the pedipalp and other morphological details allow for the definitive family placement of this fossil in the Chaerilidae, so far represented by its sole extant genus, *Chaerilus*. This fossil is the most ancient known record for any of the four extant scorpion lineages ("trichobothrial Type B"; parvorder Chaerilida), and the first Mesozoic record of an extant scorpion family.

Key words: Chaerilidae, scorpion, amber from Burma, fossil, Cretaceous.

Taxonomy:
Electrochaerilinae subfam. n.
Electrochaerilus gen. n.
Electrochaerilus buckleyi sp. n.

Un nuevo género y una nueva subfamilia de escorpiones del ámbar del Cretácico Inferior (Scorpiones: Chaerilidae)

Resumen:

Electrochaerilus buckleyi sp. nov., *Electrochaerilus* gen. nov. y Electrochaerilinae subfam. nov. son descritos del ámbar del Cretácico Inferior (Albiano Superior; edad aproximada es 98,9–112,2 Ma) de Burma (Myanmar). El patrón tricobotrial observable en el pedipalpo y otros detalles morfológicos permiten la identificación definitiva de este fósil en Chaerilidae, que está representado, hasta donde se conoce, por un solo género vivo, *Chaerilus*. Éste fósil es el récord más antiguo conocido de los cuatro linajes de escorpiones sobrevivientes ("trichobothrial Type B"; parvorden Chaerilida) y el primer récord del Mesozoico de una familia de escorpión viviente.

Palabras clave: Chaerilidae, escorpión, ámbar de Burma, fósil, Cretácico.

Taxonomía:
Electrochaerilinae subfam. n.
Electrochaerilus gen. n.
Electrochaerilus buckleyi sp. n.

Introduction

One scorpion, a juvenile, was recently described from the Lower Cretaceous Burmese amber (Burmite) as *Palaeoburmesebuthus grimaldii* Lourenço, 2002; its type is deposited at the American Museum of Natural History (AMNH), New York. The updated age of Burmese amber is Upper Albian, 112.2–98.9 Ma (Harland *et al.,* 1990; Gradstein *et al.,* 1995; Poling, 1997; Cruickshank & Ko, 2003). *Palaeoburmesebuthus grimaldii* was not assigned to any family. An older conspecific instar was later described from Burmese amber and it is deposited in the Natural History Museum, London, England (BMNH, Santiago-Blay *et al.*, in press). The collecting localities for both Burmese amber scorpion specimens deposited at the AMNH and at the BMNH are likely from the same area (Ross, in press). We report the third scorpion from Burmese amber, also a juvenile, which belongs to a new genus and a new subfamily of family Chaerilidae, so far represented by the sole extant genus *Chaerilus*.

According to Lambert *et al.* (1999), the solid state nuclear magnetic resonance spectra of amber samples from Burma are similar to those from the mid-Eocene Claiborne Formation in Arkansas (U.S.A.) and to samples of amber from Australia and Papua New Guinea, suggesting a common paleobotanical source. Grimaldi *et al*. (2002) indicate that the source of burmite amber is possibly *Metasequoia* (Taxodiaceae).

Methods & Material

Photography was performed by using a dissecting microscope (Nikon SMZ-10) equipped with a digital camera (Nikon E995) and a fiber optics light source (Nikon Inc., Crescent 90) and lens adapter (Zarf LNS 2330D, 10 times wide-field magnification). The fossil specimen was imaged while keeping the surface closest to the scorpion covered by a drop of glycerin under a cover slip. Additional photography of *Chaerilus celebensis* was performed by using a dissecting microscope (Wild Photomakroscop M 400), equipped with a digital camera (JVC KY-F70) and two light sources (Opelco DDL fluorescent ring light and a Bunton EKE fiber optic) and electronically integrating images taken at slightly different focal planes using the Auto-Montage computer program (Synchroscopy, Frederick, Maryland, USA). Measurements and terminology follow Sissom *et al*. (1990) and Soleglad & Fet (2001, 2003b).

The holotype of *E. buckleyi* **sp. nov.** described herein is deposited in a private collection. Although the International Code of Zoological Nomenclature (ICZN, 1999) contains Recommendation 16C on "Preservation and Deposition of Type Specimens" which states "authors should deposit type specimens in an institution that maintains a research collection", this recommendation is not binding. Being in violation of a Recommendation does not lead to invalidity, which may happen if an author is in violation of an Article. The only mandatory requirement stated by the Article 16.4.2 calls for the statement indicating the name and location of the collection where the type specimen is deposited. It is a common practice among paleontologists to describe the unique type specimens from private collections, as was the case, for example, with another scorpion, *Archaeobuthus estephani* Lourenço, 2001; some drosophilid flies (Grimaldi, 1987) and some halictid bees (Engel, 1997), all entombed in amber; and some Carboniferous hexapods (Kukalová-Peck, 1987). Furthermore, the Code does not in any way regulate the ownership of specimens.

Comparative recent scorpion material. Chaerilus celebensis Pocock, 1894, Luzon, Philippines, & (WDS), Mapur Island, Indonesia, & juvenile (VF); *Chaerilus chapmani* Vachon & Lourenço, 1985, Palawan Island, Philippines, & (FK); *Chaerilus tichyi* Kovařík, 2000, Pahang, Malaysia, & paratype (FK); *Chaerilus tryznai* Kovařík, 2000, Bomi, Tibet, & paratype (FK); *Chaerilus variegatus* Simon, 1877, Indonesia, ♂ (MES).

Abbreviations. List of depositories: FK, Personal collection of František Kovařík, Prague, Czech Republic; MES, Personal collection of Michael E. Soleglad, Borrego Springs, California, USA; VF, Personal collection of Victor Fet, Huntington, West Virginia, USA; WDS, Personal collection of W. David Sissom, Canyon, Texas, USA.

Systematic Description

Order SCORPIONES C. L. Koch, 1850

Suborder Neoscorpiones Thorell & Lindström, 1885

Infraorder Orthosterni Pocock, 1911

Parvorder Chaerilida Soleglad & Fet, 2003

Superfamily Chaeriloidea Pocock, 1893

Family Chaerilidae Pocock, 1893

Subfamily Electrochaerilinae, subfam. nov.

TYPE GENUS. *Electrochaerilus*, gen. nov

DIAGNOSIS. With characters of the genus *Electrochaerilus*, gen. nov.

Genus *Electrochaerilus*, gen. nov.

TYPE SPECIES. *Electrochaerilus buckleyi*, sp. nov.

DIAGNOSIS. With characters of the type species.

ETYMOLOGY. Genus, *Electrochaerilus*, from Greek, *elektron*, typically meaning amber, and *Chaerilus*, the only confamilial genus in the Chaerilidae. Gender masculine.

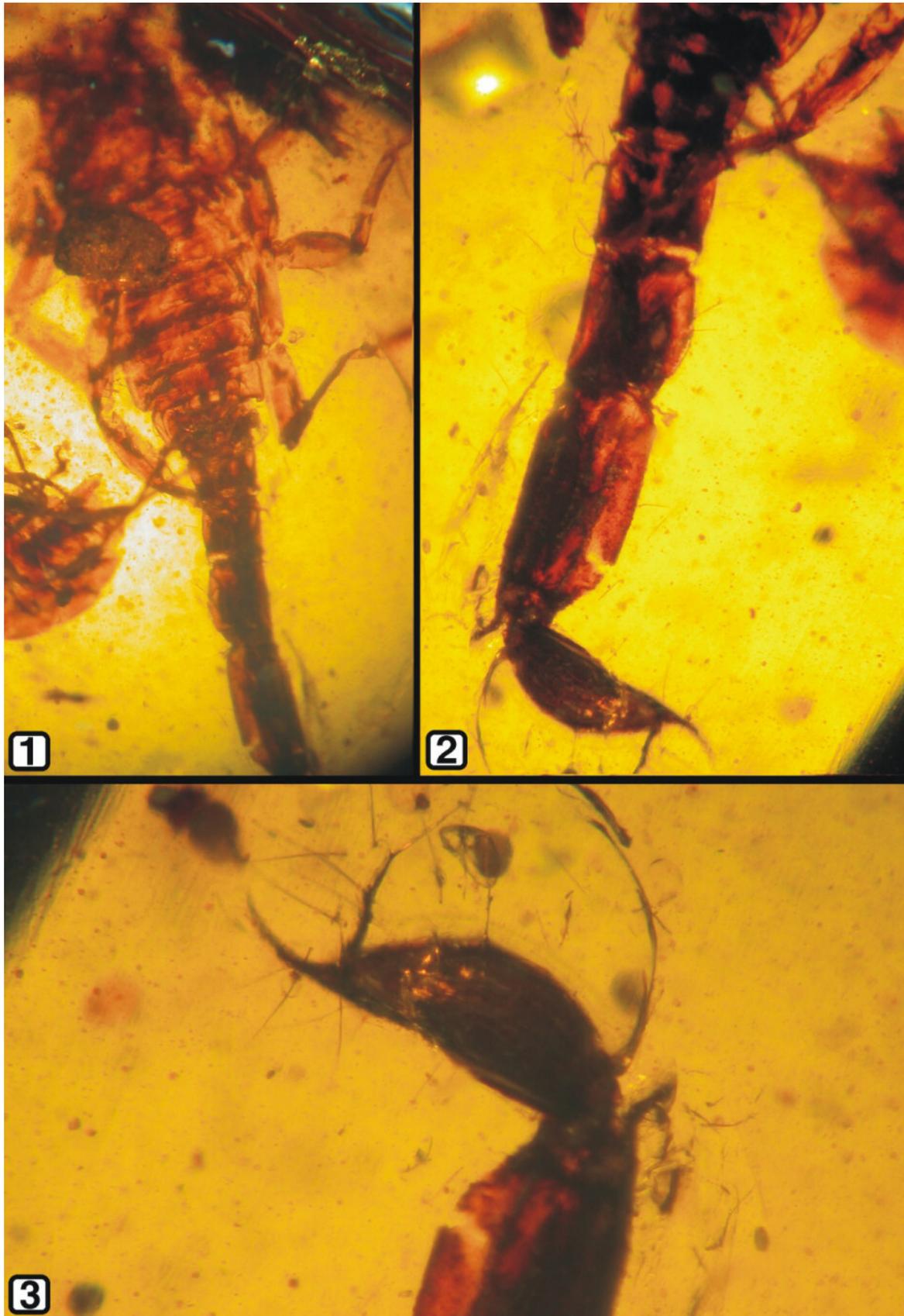### *Electrochaerilus buckleyi*, sp. nov.
Figs 1–18.

DIAGNOSIS. Denticles on the dorsal aspect of the cheliceral fixed finger are closely grouped in the basal half of the finger (Fig. 16); in particular, the subdistal (*sd*) denticle is situated quite close to the median (*m*) and basal (*b*) denticles. Chelal trichobothrium *V* on the pedipalp is positioned close to the movable finger external condyle (Fig. 10). The pectinal fulcra are missing (Fig. 17).
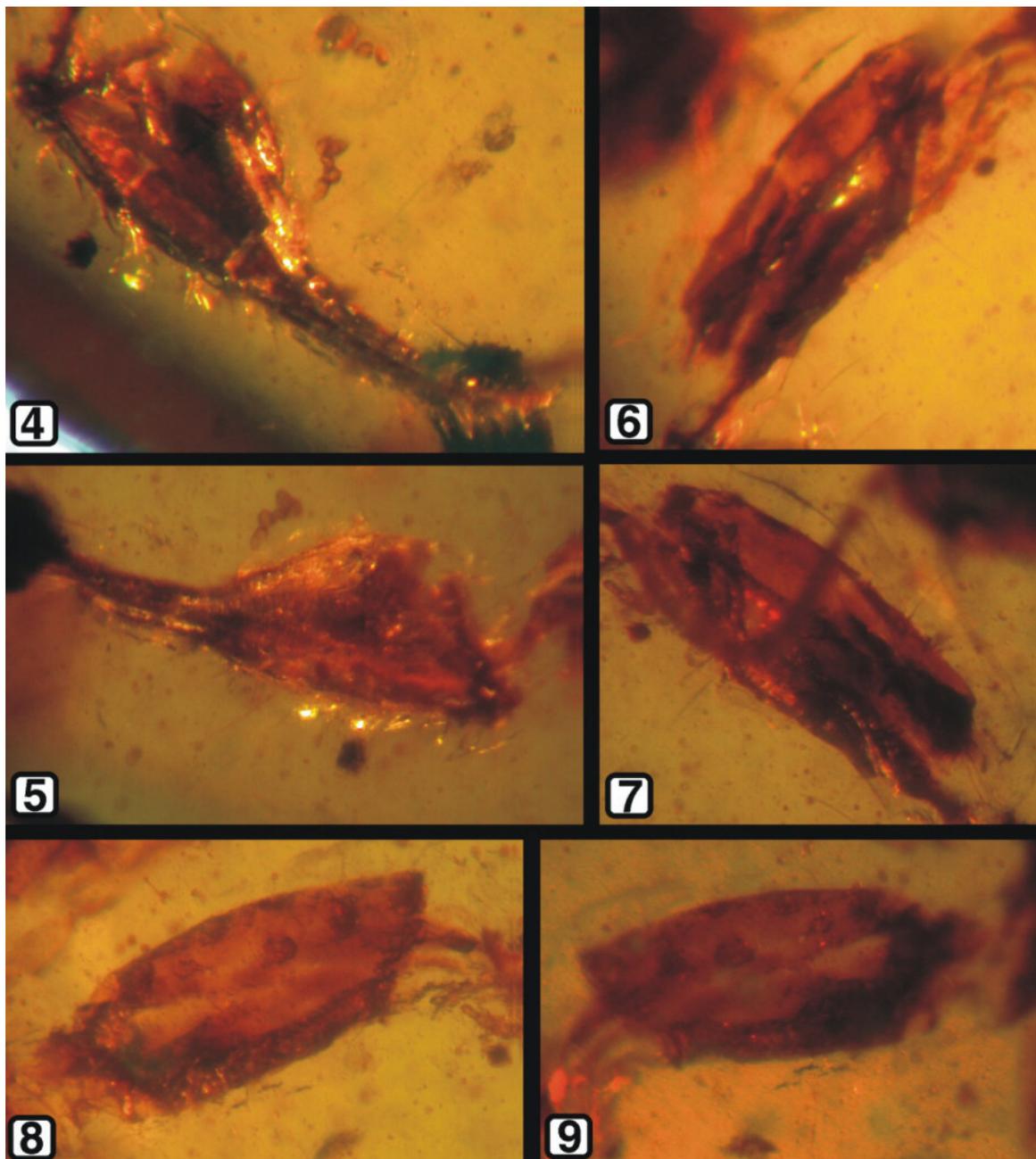
HOLOTYPE. A juvenile female. Deposited in the private collection of Ron Buckley (Florence, Kentucky, USA). Burmese amber; Tanai Village (on Ledo Rd. 105 km NW of Myitkyna), Hukawng Valley, Kachin, Myanmar (Burma), coll. Leeward Capital Corporation, 2003.

RANGE AND REMARKS. The age estimates of Burmese amber have varied considerably (Cruickshank & Ko, 2003). For instance, Zherikhin & Ross (2000) and Grimaldi *et al*. (2002) considered this age to be probably 90–100 Ma (Turonian–Cenomanian, Cretaceous), while Lourenço (2002: 97) gives the age as ±90 Ma. We follow the most recent age estimates for Burmese amber deposits (Cruickshank & Ko, 2003), which date these materials as being somewhat older, 98.9–112.2 Ma (Upper Albian, Lower Cretaceous), based on ammonites and palynomorphs for one amber locality.

ETYMOLOGY. The specific epithet, *buckleyi*, a patronym in honor of Mr. Ron Buckley, in whose collection the holotype is deposited.

Figs. 1–3. *Electrochaerilus buckleyi* **sp. n. 1.** Carapace, mesosoma, and metasoma, dorsal view. **2.** Metasoma and telson, lateral-dorsal view. **3.** Telson, lateral view.

Figs. 4–9. *Electrochaerilus buckleyi* **sp. n.**, segments of left pedipalp. 4. Chela, ventral view. 5. Chela, dorsal view. 6. Patella, ventroexternal view. 7. Patella, dorsointernal view. 8. Femur, dorsointernal view. 9. Femur, ventrointernal view.
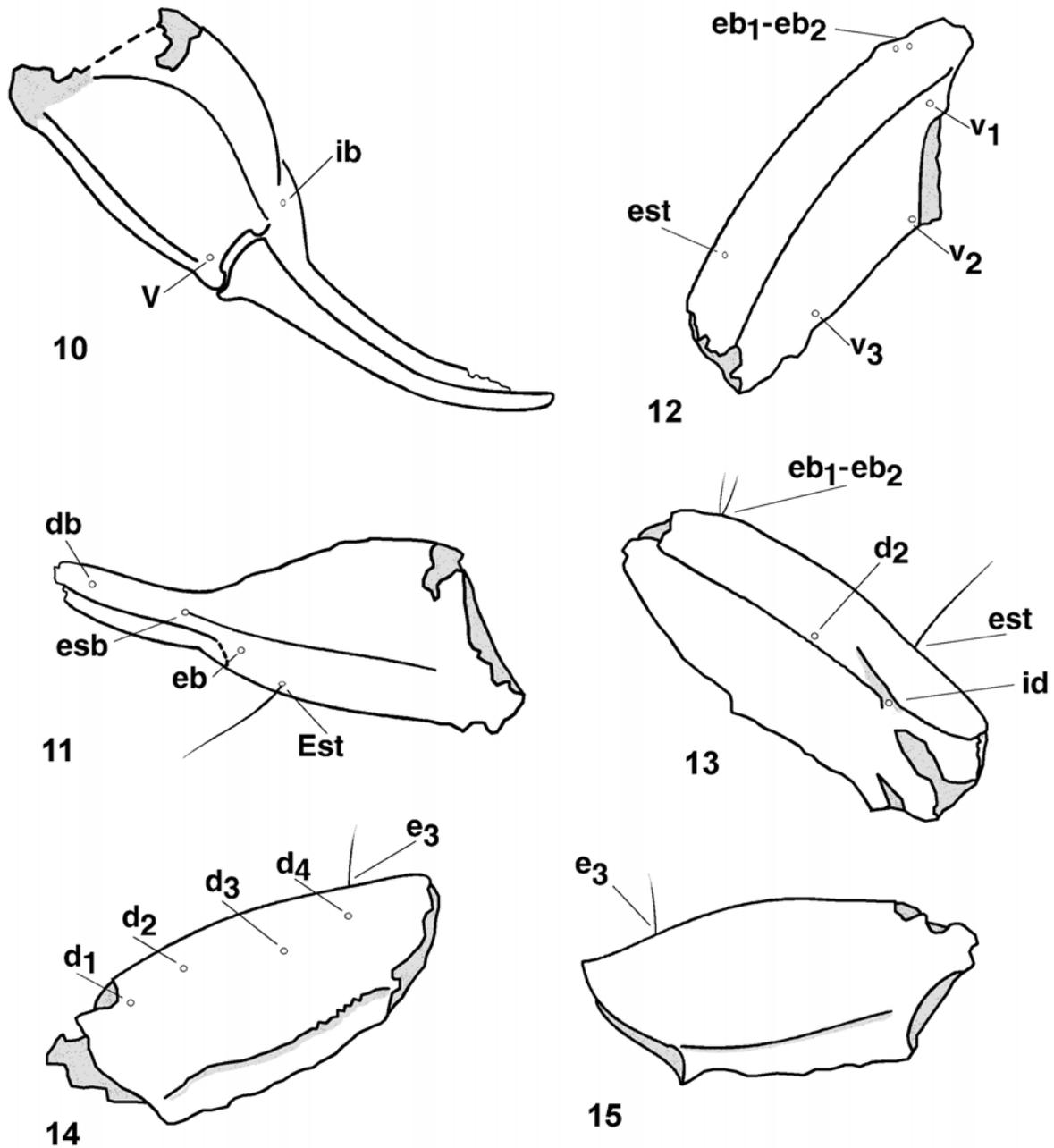
DESCRIPTION.

Amber piece. Pale yellow-brown, translucent rectangular plate. Piece dimensions: maximum length, 13.3 mm; maximum width (perpendicular to maximum length), 6.8 mm; maximum depth, 3 mm. Other inclusions in the piece are a wasp and organic debris. Piece is stored in acid free environment in a safety deposit box.

General appearance of the specimen (Fig. 1). A flattened juvenile female, judging from restricted area occupied by pectinal tooth sensilla, can be seen from dorsal and, in part, ventral views. Because ventral side

is embedded deeper, its view is often unclear as are the lateral views.

Basic color. Pale brown, darker distad on metasoma; no visible coloration patterns; dried muscular tissue makes some areas darker especially due to a thinner cuticle in the juvenile.

Measurements (in mm). *Carapace*. Anterior width obscured; posterior width 2.0; median length 1.52. *Chelicerae*. Width at the base, 0.8; fixed finger length 0.68, width 0.32. *Coxosternal area* (after Soleglad & Fet, 2003a): coxa II length 1.90; coxa III length 1.90;
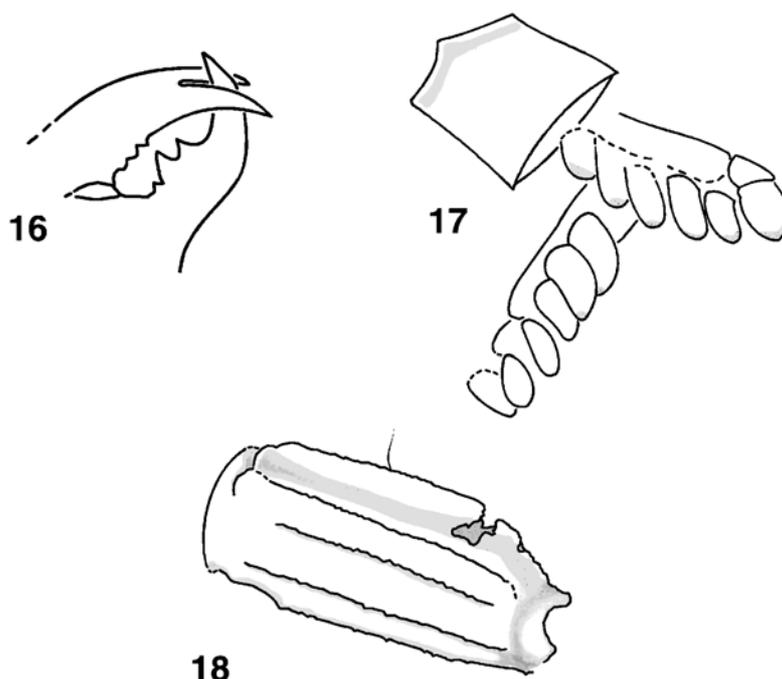
Figs. 10–15. *Electrochaerilus buckleyi* **sp. n.**, diagrammatic outline of segments of left pedipalp showing identified *trichobothria*. **10.** Chela, ventral view. **11.** Chela, dorsal view. **12.** Patella, ventroexternal view. **13.** Patella, dorsointernal view. **14.** Femur, dorsointernal view. **15.** Femur, ventrointernal view.

coxa IV length 1.90; sternum: anterior width 1.8, posterior width 2.4, apex length 1.7, apex lateral length 0.8. *Pedipalp*. Femur length 1.52, width 0.72; patella length 2.0, width 0.72; chela palm length 2.48, width 0.76; fixed finger length 1.12; movable finger length 1.36. *Mesosoma*. Total length 2.84. *Pectines:* left, length 1.24, width 0.44; right, length 1.24, width 0.52. *Legs*. Leg III tarsus length 0.44, tarsus basal width 0.40; basitarsus length 0.80, tibia length 0.56, patella length 1.08, femur length 1.20. *Metasoma & telson*. Segment I: length/width (L/W) 0.56/1.12; segment II: L/W 0.68/0.92; segment III: L/W 0.76/0.84; segment IV: L/W 1.08/0.72; segment V: L/W 1.80/0.72; metasoma total length (without telson) 4.88; telson length 1.88; vesicle depth 0.52. *Total* length (carapace + mesosoma + metasoma + telson) 11.12.

Carapace (Fig. 1). Irregular coloration pattern. No carination, anterior aspects damaged; median and lateral eyes completely obscured. Posterior aspect of the carapace quite wide, lateral edges tapering considerably anterad (Fig. 1).

Chelicerae (Fig. 16). Coloration uniform, denticles pigmented darker. Observable both from dorsal and

Figs. 16–18. *Electrochaerilus buckleyi* **sp. n.**, diagrammatic outline of select structures. **16.** Right chelicera, ventral view. **17.** Sternum and pectines. **18.** Metasoma segment V, dorsolateral view.

ventral views. Dorsally, both chelicerae are visible protruding from carapace anterior edge; movable and fixed fingers as well as portions of the palm (basal piece?) are visible. Ventrally, right chelicera is visible. On its fixed finger, the distal (*d*) denticle is seen positioned between the two distal denticles of movable finger (*vd* and *dd*). On movable finger, dorsal and ventral distal denticles are approximately the same length, ventral being slightly longer; with three small accessory (*a*) denticles on basal portion of ventral edge; dorsal edge with three larger denticles, subdistal (*sd*), median (*m*), and basal (*b*). On dorsal aspect of fixed finger, we can see three denticles, all closely grouped on basal half of finger: subdistal (*sd*), median (*m*), and basal (*b*), latter two positioned directly on fixed finger edge, *not* conjoined on a common trunk. Accessory denticles on ventral aspect of fixed finger not visible.

Coxosternal area (Fig. 17). Sternum pentagonal, large, without fold or groove. Maxillary lobes visible, moderately protruding forward as in modern Chaerilidae. Coxae II–IV visible on both sides.

Pectines (Fig. 17). Both pectines visible, each with six teeth and no fulcra; setation essentially absent. Teeth somewhat short and oval. Areas occupied by pectinal sensilla clearly visible, sensilla not numerous and limited only to the tip of a tooth, which indicates a female. A short, semi-round distal anterior lamella visible on left pecten, above the most distal tine.

Genital operculum. Obscured, portions visible at posterior edge of sternum, appearing twisted horizontally.

Legs (Fig. 1). Seven legs visible (except right leg I) but flattened, details not clear. No tibial or tarsal spurs. No visible setation, no bristlecombs. Ungues not elongated, moderately curved. Tarsus, basitarsus, tibia, and patella stocky, not elongated. Patella is rounded. Tarsal setation unclear: several large stout setae visible laterally on distal part of left leg II tarsus and other segments.

Mesosoma (Fig. 1). Tergites without carination or setation; arthrodial membrane flattened. Sternites without carination and with very sparse setation; spiracles not visible, posterior edge obscured. Lateral denticles present on posterior edge of sternite V.

Metasoma (Figs. 1–2, 18). Twisted; ventrolateral view available. Metasoma darkened distally (segment V and telson). All segments, especially V, have chagrined microsculpture consisting of minute punctations; very sparse setation. Segment I extremely short; segment V the longest. Dorsolateral carinae present, with 1–2 setae per carina on segments IV and V. Other carination on segments I–IV not clearly visible. Carination of segment V (Fig. 18) well expressed, observable lateroventrally as four equally spaced, crenulated carinae, from the left: dorsal lateral, lateral, ventrolateral, and ventromedian; therefore there are 7 projected carinae. Dorsal furrow clearly expressed on segment V and portion of IV; its edges are rounded. No denticle-like, lobe-like, or angular extensions at the distal end of segments.

Telson (Figs. 2–3). Telson pale brown, darkened toward aculeus, teardrop-shaped, without carination, not flattened, with a number of long sparse setae like the rest of metasoma. No subaculear tubercle. Vesicle-

aculeus juncture distinct. Moderate longitudinal furrow starts at the base of telson extending halfway. Aculeus moderately curved.

Pedipalp (Figs. 4–9, 10–15). Left pedipalp complete; only right pedipalp coxa available. Some areas of left pedipalp obscured by compression or debris (tips of fingers). Non-obscured areas allow good view of trichobothrial areolae; some trichobothrial hairs visible in projection even when areola is out of view. Trichobothrial areola ca. 0.1 mm in diameter. Internal and especially external surfaces almost totally obscured by compression due to desiccation but some trichobothria visible from ventral view. Ventral and dorsal surfaces are well visible, except for distal half of fixed finger, and therefore, we are confident that we observed *all* trichobothria present on ventral and dorsal surfaces (usually as circular areolae with a defined circumference).

Trichobothria (Figs. 10–15). Total 19 observed: dorsal aspect, six (one on chela, one on patella, four on femur); internal aspect, two (one on chela, one on patella); ventral aspect, four (one on chela, three on patella); external aspect, seven (three on chela, three on patella, one on femur).

Femur (Figs. 8–9, 14–15). Dorsointernal carina well-expressed, distinctly granulate. Internal surface obscured. No trichobothria on ventral aspect (surface is well observable). No visible carination ventrally, ventral tubercle line extends down to the base. Trichobothria: Four trichobothria are observable on dorsal aspect: d_1, d_3, d_4, and d_5, with d_2 missing according to indexation of Soleglad & Fet (2003b); trichobothria positioned in almost straight line, slightly curved externally. Internal surface obscured. No trichobothria on ventral aspect (surface is well observable). At least one trichobothrium on external aspect (e_3?) visible as a hair in profile projection from ventral view.

Patella (Figs. 6–7, 12–13). Ventral patellar spine (VPS) small, pointed, located on VPS_c carina (terminology of Soleglad & Fet, 2003b) as in extant Chaerilidae. Dorsal patellar spine (DPS) absent. No clear vaulted appearance to ventromedian edge (however, the specimen is flattened). Trichobothria: Dorsal surface not well observable but a long hair of a dorsal trichobothrium (d_2) visible in profile projection from ventral view basally to the VPS position. An internal trichobothrium, distally located and well visible from the dorsal aspect, is i_1 ($= id$). The rest of internal surface is obscured. Three trichobothria found on ventral aspect: v_1, v_2 and v_3, evenly spaced along the length of patella, trichobothrium v_1 close to the distal edge and not on located carina, while v_2 and v_3 are positioned on a long ventrointernal carina (VI_c). Ventral surface is well observable, and no other trichobothria are present. At least three trichobothria are visible on external aspect. One trichobothrium, *est* of subterminal series visible from dorsal view as a hair in profile projection at the level of *id*. Two trichobothria, eb_1 and eb_2 of basal series, visible

from dorsal view at base, the former as a hair in profile projection, and the latter as an areola.

Chela (Figs. 4–5, 10–11). Rather strong and robust, not slender, palm moderately wide, fingers moderately long and thin, slightly curved. Surface finely chagrined dorsally and externally, covered with setae. Both external and internal movable finger (MF) condyles visible; fingers closed, dentition not visible. Ventroexternal carina (V1) is well developed, terminates distally in straight line to the external condyle; ventromedian carina (V2) weak or obsolete; ventrointernal carina (V3) present; dorsointernal carina (D5) visible although inner basal aspect of palm is damaged. Distal ends of both fingers obscured by debris. Trichobothria: One trichobothrium on dorsal aspect of fixed finger, *db*, (area where *dt* is expected of fixed finger is obscured by debris). Dorsal surface is well observable. One trichobothrium on internal surface visible from ventral aspect, a well-visible *ib*, located on chela at the same level as trichobothrium *V*. The rest of internal surface obscured (area where *it* is expected not visible). One trichobothrium found on ventral aspect, *V,* under the junction of chela manus and movable finger, close to ventroexternal carina. Ventral surface well observable, and no other trichobothria are present. At least three trichobothria on external aspect: two on fixed finger, *eb* and *esb*, and *Est* on chela, visible only as a hair in profile projection.

Discussion

The described fossil specimen is placed into family Chaerilidae according to the combination of very distinct features, all discernible in the fossil specimen. Chaerilidae is an extant monotypic family, with the only genus *Chaerilus* Simon, 1877 in South and Southeast Asia (18 species; Kovařík, 2000), and no fossils known up to date. Soleglad & Fet (2003b) diagnosed Chaerilidae (as well as superfamily Chaeriloidea and parvorder Chaerilida, which include only this family) by the following features: "Synapomorphies: Orthobothriotaxy type B; pedipalp femoral d_3–d_4 trichobothria configuration points toward dorsoexternal carina; cheliceral fixed finger with median and basal denticles flush on surface, not conjoined on common trunk; sternum, *type 1*, exhibits subtle wide horizontal compression; maxillary lobes I spatulate; hemispermatophore is *fusiform*; pedipalp patella with "6-carinae" configuration. Important Symplesiomorphies. Median denticle row (MD) of pedipalp chelal finger arranged in *oblique* groups; pedipalp chela exhibits "8-carinae" configuration; ventral edge of cheliceral movable finger crenulated; dorsal edge of cheliceral movable finger with a single subdistal denticle; ventral surface of cheliceral fixed finger with denticles; leg tibial spurs absent." This diagnosis is based on the extant genus *Chaerilus*. Fig. 19 illustrates the extant Type B trichobothrial pattern for *Chaerilus variegatus* Simon, 1877, and Figs. 28–31 depict various morphological features of a juvenile *Chaerilus celebensis* Pocock, 1894.
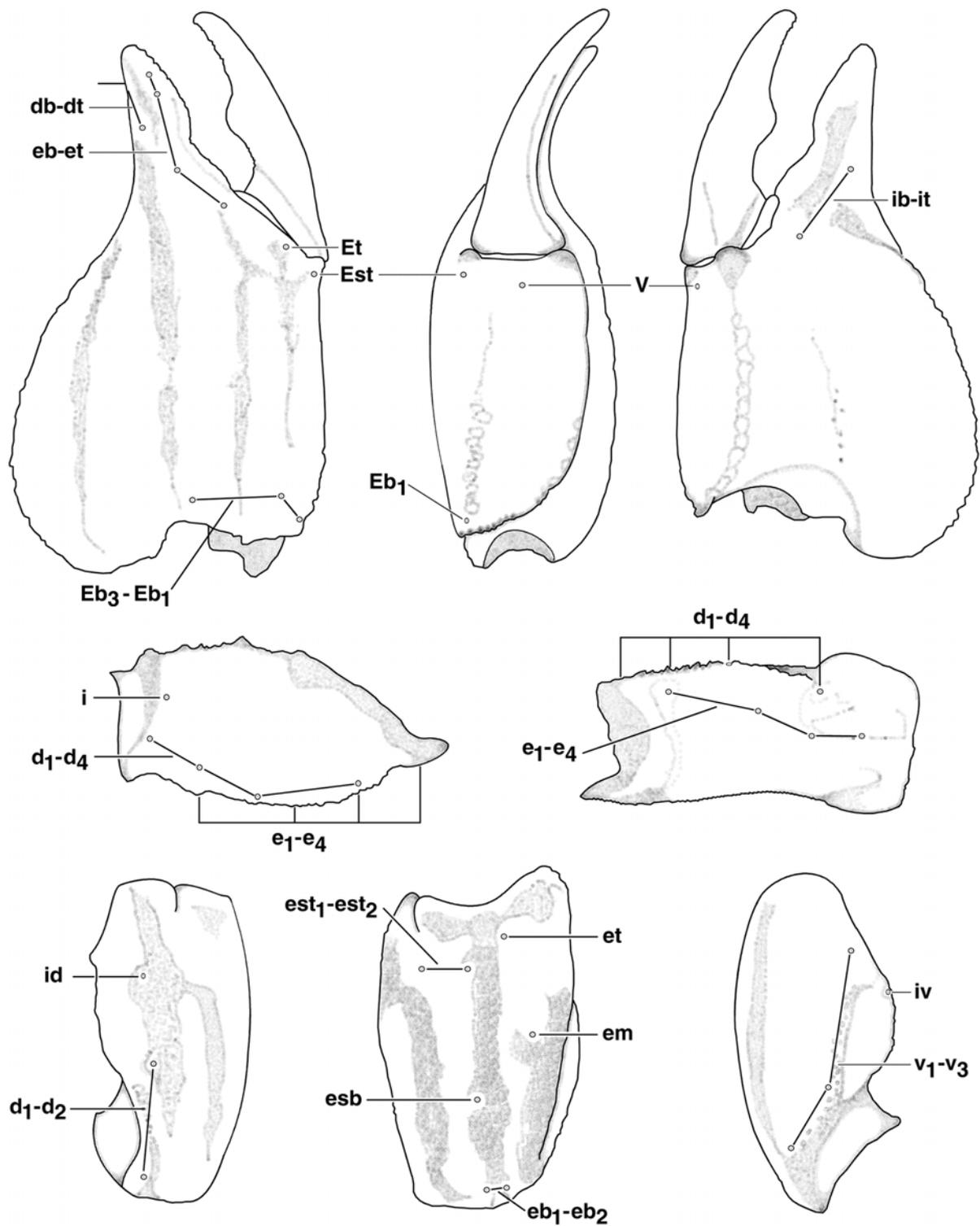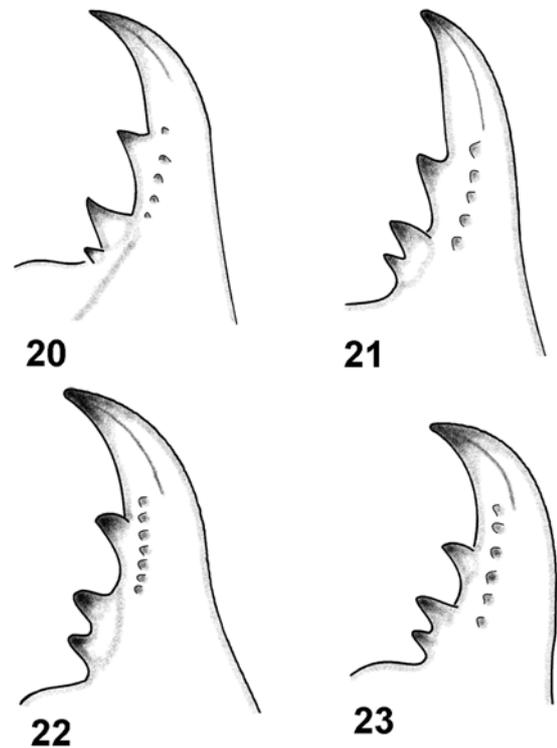
Fig. 19. Orthobothriotaxy Type B (parvorder Chaerilida) as seen in *Chaerilus variegatus*. Chela (top), external, ventral and internal views. Femur (middle), dorsal and external views. Patella (bottom), dorsal, external and ventral views.

Of the diagnostic features listed above, only dentition of pedipalp finger could not be observed in the fossil, and the carination of pedipalp segments is observed partially. The combination of the most important features, such as Type B orthobothriotaxy, type 1 sternum, and spatulate maxillary lobes I, unmistakably diagnose the new Burmese amber fossil as a member of Chaerilidae. Secondary characters found in *Chaerilus* (but not necessarily exclusively in this genus), are also matched in the fossil specimen: well-developed lateral carinae of metasomal segment V; the simple two-plate anterior lamellae configuration of the pectines; the essential absence of the chelal ventromedian carina (V2); the distal termination of the chelal ventroexternal carina (V1) to the external condyle; the anterior tapering carapace; crenulation on the ventral edge of the cheliceral movable finger; the subequal distal denticles of the movable finger of the chelicerae; absence of tibial spurs on legs III-IV; and absence of a subaculear tubercle or tooth.

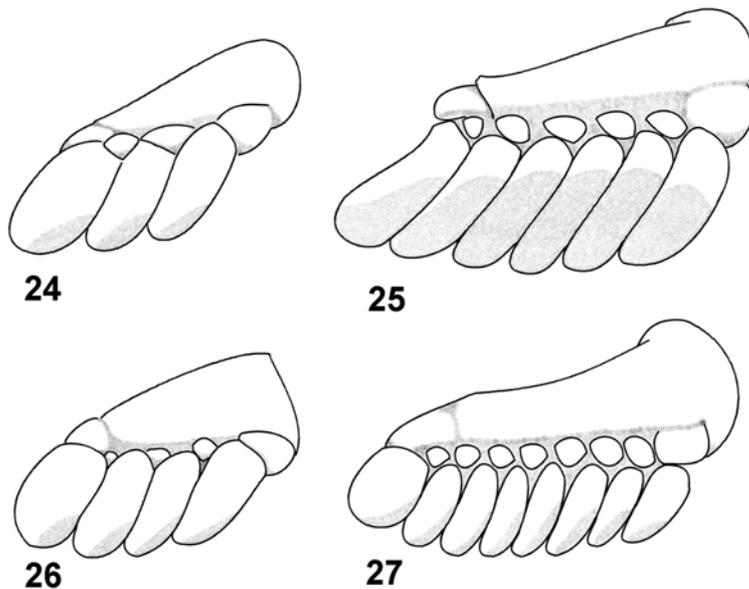The main differences between the fossil specimen and *Chaerilus* are as follows:

(a) *Cheliceral dentition*: In Figs. 20–23, we illustrate the typical dentition of the cheliceral fixed finger of four *Chaerilus* species. Note in particular, that *sd* is essentially equidistant between the distal tine (*d*) and denticles *m* and *b*. This configuration is also illustrated for *C. variegatus* (Soleglad & Fet, 2003b: Fig. 58), *C. granulatus* (Stockwell, 1989: Fig. 53), and the "generic" *Chaerilus* in Vachon's (1963: Fig. 3) important paper which was the first to classify fundamental cheliceral dentition patterns. In contrast, we see in *Electrochaerilus* (Fig. 16) that *sd* is abutted next to *m*, considerably proximal to *d*.

(b) *Trichobothrium V on chela*: The externally oriented, single trichobothrium *V* exhibited in *Electrochaerilus* is conspicuous when compared to the, in general, medially positioned *V* in *Chaerilus* (compare Figs. 10 and 19). In the material we examined (including Stockwell's (1989: Fig. 94) trichobothrial pattern illustrated for *C. granulatus*) we see that *V* is positioned essentially equidistant between the two movable finger condyles, exhibiting a ratio value range (mean) of 0.403–0.583 (0.481) when the distance between *V* and the external condyle is divided by the distance between internal and external condyles (note, this distance is measured from the outside aspect of the condyles). In *Electrochaerilus*, this ratio value is 0.286 implying a significant proximity to the external condyle.

(c) *Pectines*: The pectines of *Chaerilus* are quite unique (Figs. 24–27). The structure of the anterior and middle lamellae is quite simplistic, only two anterior lamellae are present: one elongated basal lamella and a small reduced lamella situated on the distal aspect of the pecten, abutting the distal tooth. The middle lamellae are essentially absent except

Figs. 20–23. Fixed finger of chelicerae, ventral view, of representative species of *Chaerilus* showing relative alignment of denticles. **20.** *C. chapmani*. **21.** *C. celebensis*. **22.** *C. tichyi*. **23.** *C. tryzni*.

for a single sclerite positioned at the basal aspect of the proximal tooth. The number of pectinal teeth is also quite reduced in *Chaerilus*: Kovařík (2000) reported a range of 3-10 (5) (spanning both sexes) for 18 species, the highest number found in the largest species, *C. tichyi* (70+ mm in length). In stark contrast to this somewhat simple pectinal development, we see in *Chaerilus* well-developed fulcra, even in troglobitic species with small pectines (i.e., *C. chapmani* in Fig. 24). In contrast, we see that the fulcra are missing in *Electrochaerilus* (Fig. 17).

The observed differences are sufficient to diagnose a new genus, *Electrochaerilus*. We also consider these differences substantial enough to establish a new subfamily, Electrochaerilinae, **subfam. nov.**, with the characters of the new genus. In extant scorpion taxonomy, subfamilies are defined in seven families (Caraboctonidae, Chactidae, Euscorpiidae, Liochelidae, Scorpionidae, Superstitioniidae, Urodacidae; Soleglad & Fet, 2003b), according to significant variations in trichobothrial number and position, cheliceral and pedipalp dentition, and other characters. Therefore, the family Chaerilidae now has two monotypic subfamilies: the nominotypic Chaerilinae Pocock, 1893 (which includes *Chaerilus* Simon, 1877) and Electrochaerilinae, **subfam. nov.** (which includes *Electrochaerilus*, **gen. nov.**).

Figs. 24–27. Pecten of representative species of *Chaerilus* showing well-developed fulcra. **24.** *C. chapmani*, female. **25.** *C. variegatus*, male. **26.** *C. celebensis*, female. **27.** *C. tichyi*, female.
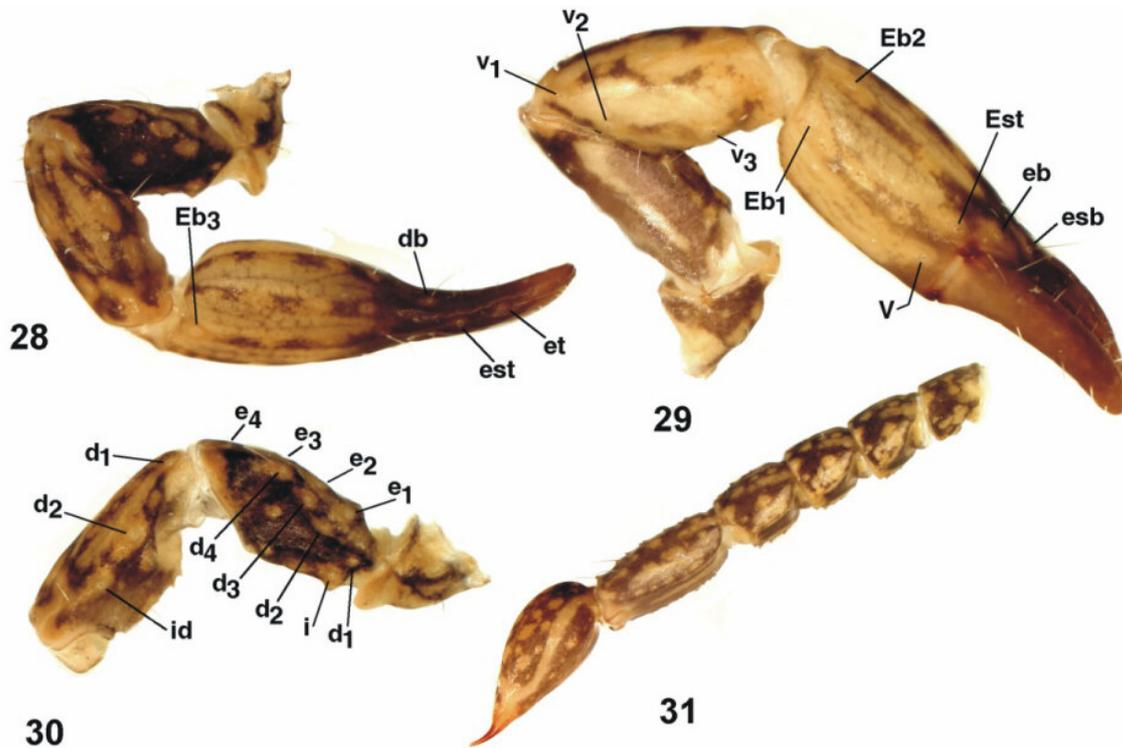
Kjellesvig-Waering (1986), in his comprehensive review of fossil scorpions, did not list any Cretaceous taxa. Later, five Cretaceous scorpion genera (infraorder Orthosterni) have been described: non-amber *Araripescorpius* Campos, 1986 (family placement unclear) and *Protoischnurus* Carvalho & Lourenço, 2001 (Protoischnuridae) (both from the Santana Formation, Brazil, 120–100 Ma; Carvalho & Lourenço, 2001; Santiago-Blay *et al.*, 2001); *Archaeobuthus* Lourenço, 2001 (Lebanese amber, 135–130 Ma; Lourenço, 2001) (Archaeobuthidae); *Palaeoburmesebuthus* Lourenço, 2002 (Burmese amber; Lourenço, 2002) (family placement unclear); and *Palaeoeuscorpius* Lourenço, 2003 (amber of southwestern France, ca. 100 Ma; Lourenço, 2003) (Palaeoeuscorpiidae). Note that Lourenço (2001, 2002) gives the Lebanese amber age as approximately 130–125 Ma, while it is estimated by Schlee (1990) and Poinar & Milki (2001) as approximately 135–130 Ma (Valanginian or Hauterivian to Barremian). Therefore, the known five Cretaceous fossil scorpion genera span the period from Valanginian to Upper Albian (approximately 135 to 100 Ma). None of the previously reported Cretaceous scorpion genera belonged to an extant family.

Soleglad & Fet (2001) identified four extant and two fossil trichobothrial patterns in the Orthosterni, one for the Upper Carboniferous Palaeopisthacanthidae (290 Ma), Type P, and one for the Cretaceous Archaeobuthidae (135–130 Ma), Type F1. The trichobothrial Type A pattern, identified for the Buthidae, has been established in fossils from Paleocene to Eocene (65–55 Ma) based on five genera described by Lourenço & Weitschat (1996, 2000, 2001) from Baltic amber (see Santiago-Blay *et al.*, in press, for a detailed discussion of the controversial genus *Palaeoburmesebuthus* Lourenço, 2002 from Burmese amber). *Electrochaerilus*, ca. 100 Ma, falls approximately in the middle of the timelines for Archaeobuthidae and Buthidae, and marks the lowest known boundary of the Type B, or Chaerilidae. It is the most ancient known record for any of the four extant trichobothrial types, or parvorders in terms of Soleglad & Fet (2003b). It is also the first Mesozoic record for an extant scorpion family.

What makes the discovery of *Electrochaerilus* even more fascinating is that its sister group, the extant genus *Chaerilus*, is still found in the same geographic region and same type of habitat. The Burmese locality now lies at 25.5°N, and its paleolatitude was 12°N, corresponding to a distinct tropical biota (Ross, 1998; Rasnitsyn & Ross, 2000; Ross & York, 2000; Grimaldi *et al.*, 2002). Therefore, the general habitat conditions for *Electrochaerilus* and *Chaerilus* were similar. Most species of *Chaerilus* are widely found in tropical landscapes in India, Vietnam, Malaysia, Philippines, and Indonesia; some venture into the higher mountains of Nepal and Tibet (Fet, 2000; Kovařík, 2000). The only species of *Chaerilus* currently found in Burma is *C. variegatus* Simon, 1877 (Kovařík, 2000).

Finally, *Electrochaerilus* is now the second species of scorpions known from the Cretaceous tropical ecosystem that produced Burmese amber. The first such species, *Palaeoburmesebuthus grimaldii*, was described by Lourenço (2002) and further discussed by Santiago-Blay *et al.* (in press; second specimen). The family placement of *Palaeoburmesebuthus* is not clear; however, it belongs to another family, superfamily, and parvorder than *Electrochaerilus*. Finding representatives of several scorpion families in the same habitat is not unusual; modern tropical ecosystems, including those of Southeast Asia, are normally inhabited by representatives of three to four scorpion families. The Cretaceous fossils of Crato formation in Brazil, approximately of the same age as Burmese amber, contain representatives of at least two families (Carvalho & Lourenço, 2001; P. Selden & F. Menon, pers. comm., 2004).

Figs. 28–31. A juvenile *Chaerilus celebensis*. 28. Right pedipalp, dorsal view, showing trichobothria. 29. Right pedipalp, ventral view, showing trichobothria. 30. Pedipalpal femur and patella, dorsal view, showing trichobothria. 31. Metasoma and telson, lateral view.

Investigation of Mesozoic scorpions is crucial for our understanding of the evolution of this "essentially fossil group" (Kjellesvig-Waering, 1986). Soleglad & Fet (2003b) suggested that four extant lineages of orthostern scorpions should have been established during Permian to Triassic time. Further through Cretaceous, many animal taxa persisted as relicts while other perished during the global restructuring of ecosystems (Zherikhin, 1978). Among the four extant scorpion lineages, two (parvorders Buthida and Iurida) experienced a Tertiary boost of radiation while two others (Pseudochactida and Chaerilida) remain only as relicts in Asia, each represented only by one genus. Our current discovery of *Electrochaerilus* adds another piece to this relict puzzle.

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